

DESCRIPTIONS OF THE SPECIES OF HELIASTER (A GENUS OF STAR-FISHES) REPRESENTED IN THE U. S. NATIONAL MUSEUM.

By RICHARD RATHBUN.

(With four plates.)

Genus HELIASTER Gray.

(Ann. and Mag. of Nat. Hist., vi, p. 179, 1840.)

The section *Heliaster*, since recognized as a genus by most authors, was established by Dr. Gray, in 1840, to include *Asterias helianthus* Lamk., from the western coast of South America, and two new and closely allied species from the Galapagos Islands, *Cumingii* and *multiradiata*, which are described in the same connection. In 1861, Mr. John Xantus added two new forms from Cape St. Lucas, Lower California, *Kubingii* and *microbrachia*, which have since been recorded from several places on the western coast of Mexico. Professor Verrill, in his Notes on Radiates,* describes many specimens of the genus which have come under his notice, but adds no new species. He refers to *Heliaster Cumingii*, with a query, several specimens from Zorritos and Paita, Peru, and remarks that Gray's *multiradiata* appears to be allied to *Kubingii* of Xantus.

The types of the species described by Xantus are still preserved in the National Museum. *Heliaster microbrachia* is represented by a single type (2017); *H. Kubingii* by a large series (630). Many specimens of both of these species, from Lower California and Western Mexico, have since been added to the Museum collection, and specimens of *H. helianthus* have also been received from South America. In 1884, Dr. W. H. Jones, U. S. N., contributed several specimens of two species from the Galapagos Islands, which the writer has been led to refer to the species originally described by Dr. Gray from the same region, although the latter's descriptions are exceedingly brief and unsatisfactory. However correct these identifications may be, it is certain that one of the species, corresponding with *H. multiradiata* Gray, is the same as *H. Kubingii* Xantus; while the other, referred to *H. Cumingii* Gray, is different from any of the species in our collection from the mainland of Western America, although approaching somewhat in shape *H. microbrachia* Xantus. Unless the specimens from Peru, referred to *Cumingii* by Professor Verrill, and which the writer has not seen, have been correctly named, it would appear that the genus *Heliaster* is represented at the Galapagos Islands by species more nearly related to those of Southwestern North America than to those of the nearest adjacent mainland.

* Trans. Conn. Acad. of Arts and Sciences, Vol. I, part 2, 1867-1871.

The most prominent features by which these four species may be readily distinguished, based, however, solely upon the specimens now in the National Museum, are as follows:

Number of rays, 30 to 40, seldom less than 36; rays free for about one-fourth to one-third their length; spines of upper surface small, very numerous, closely placed, and seldom forming regular rows excepting along the margins of the rays.—*Heliaster microbrachia* Xantus

Number of rays, 35 to 37 (sometimes as few as 24 in the young); rays free for one-fourth to one-third their length; spines of the upper surface, relatively large, subconical in the adult, short and globular in the young, rather widely separated and forming comparatively regular radiating rows outside of the disk.—*Heliaster Cumingii* Gray.

Number of rays, 32 to 35; rays free for one-half their length or slightly more, sometimes for nearly three-fourths their length; spines of upper surface variable in size, small to large, forming regular simple rows along the margins of the rays, and a single, variable medium series, generally not wide.—*Heliaster helianthus* (Lamk.) Gray.

Number of rays, 15 to 26, seldom less than 22; rays free for more than one-half their length, sometimes for over three-fourths their length, stout and well rounded; spines of upper surface large on disk, and so continuing part way down the median line of the rays; upper lateral rows of rays regular, simple, consisting of small spines; median portion of rays occupied by three rows, forming a wide series, in which the individual rows are not always distinct.—*Heliaster multiradiata* Gray (including *Heliaster Kubingii* Xantus).

Heliaster microbrachia Xantus.

Proc. Phila. Acad., xii, p. 568, 1860. Verrill, Notes on Radiates, in Trans. Conn. Acad. Arts and Sci., i, part 2, 1867-1871, pp. 290, 328, 331, 344, 594.

This species is readily distinguished by its much more numerous and closely placed abactinal spines, which are uniformly of smaller size than in any other species of the genus excepting *H. helianthus*, which occasionally agrees with it in this particular; and by the comparative shortness of the free rays, in which it corresponds only with *H. Cumingii*, of the Galapagos Islands. There are ten specimens* in the collection, all dried preparations, the most of which are in a fair state of preservation. One is the type used by Mr. John Xantus in describing the species; the others have been received from time to time during recent years, and all are from Lower California and the western coast of Mexico. Five of the specimens are below medium size, the others large. The smallest measures about 42^{mm}, the largest 96^{mm}, in the longest radius. They exhibit comparatively slight variations, although the size, shape, and arrangement of the spines differ somewhat in the different specimens.

* Very many specimens of this species have been received since this description was written, but they furnish no additional characters.

The number of rays varies from 30 to 40; in eight of the specimens there are from 36 to 40 rays. In the smallest specimen the free rays measure about 11^{mm} in length, in the larger specimens from 16 to 28^{mm}, being generally slightly longer proportionally and more gradually tapering than in *H. Cumingii*. Most of the specimens are much compressed, their thickness, however, depending upon the care taken in drying them. The abactinal surface is moderately and regularly convex, the median portion or disk proper being slightly elevated above the general contour only in the smallest specimens. The limits of the disk are, therefore, as a rule, poorly defined, the curvature of the abactinal surface passing almost imperceptibly into that of the united portions of the rays, which can generally be traced inward from the margin a considerable distance, by means of the slight grooves between them, or of the radiating rows of spines. In the smallest specimen the disk measures about 30^{mm} in diameter, or slightly more than one-third the total diameter; but in a larger specimen it is considerably less than one-third the total diameter. The grooves between the united portions of the rays are narrow and generally very shallow except directly at the margin; they are sometimes almost entirely obliterated. They usually die out about half way between the margin and the disk, but sometimes continue faintly to the latter.

The spines of the abactinal surface vary somewhat in size and shape, but are never relatively large, generally very small both in the young and adult specimens, and usually more or less uniform in appearance in each specimen, though exhibiting some variation. They are always short, and either of uniform diameter throughout their length, slightly tapering, or enlarging toward the summits, which, in the latter case, are more or less regularly rounded, and often present a fine bead-like appearance against the dark background of the surface. The spines are very closely placed over the entire surface. On the median portion or disk they are more or less uniformly scattered, but without special arrangement. On both the free and united portions of the rays, however, there is a tendency to radial arrangement, but they seldom form regular rows, except along the margins of the rays. The lateral abactinal rows, one on each side of each ray, are more or less regular, and can generally be traced nearly or quite to the disk. In the shallow grooves between them, there is usually a single row of smaller spines, and three irregular rows (becoming reduced to one or two toward the disk) can often be made out on the median portion of each ray. Generally, however, this radial arrangement of the median^{*} spines is not distinct. In one of the larger specimens, as many as seven or eight spines can be counted in the width of the broadest part of the rays. The madreporic plate is circular in outline or slightly elongated, and is generally placed about midway between the center and the margin of the disk.

The actinostome is relatively large. The adambulacral spines form a single row on each side of the ambulacral furrows, becoming reduced to single rows between adjacent ambulacra, at one-fifth to one-fourth the length of the furrows from the actinostome. These spines are comparatively large. Beginning at the actinostome, they are generally slender and acute, but where separated into two rows they form close, alternating series of large and small spines, the former, except in young specimens, usually stout and of uniform diameter throughout, but varying considerably in shape; the latter very small, crowded inwards toward the furrow, often inclining in the same direction, and mainly limited to the outer half of the furrows.

Between the adambulacral spines and the first abactinal row, there are generally, on each side of the rays, four longitudinal rows of spines, which are not, however, always regularly arranged. The three lower rows follow closely after the adambulacral row, while the fourth row is about midway between the former and the first abactinal row. The spines of the lower rows partake of the characters of the adambulacral spines, but are generally stouter, and in large specimens are often expanded and compressed at the ends. The spines of the upper lateral row are intermediate in character between those of the lower rows and the abactinal spines. The lower ventral rows extend inward toward the actinostome one-half the length of the ambulacral grooves or slightly more.

There is great variation in the size, shape, and number of the spines of the actinal surface and they afford no specific characters. In some of the specimens they are mostly stout, more or less enlarged at the ends, and blunt, flattened, or slightly bifid; in others they are more slender, tapering and acute. In the former instance they are generally closely crowded, in the latter more widely separated. The distinguishing characters are mainly those afforded by the abactinal surface and the length of the free rays.

RECORD OF SPECIMENS IN THE COLLECTION.

Lower California :

About 400 miles south of the boundary line between the United States and Mexico; C. H. Townsend, 1855 (10036, 10998).

Asuncion Island (3641).

Cape St. Lucas; John Xantus, type (2017).

Mexico :

West coast (3084, 15921).

Mazatlan: A. Forrer (10026).

Heliaster Cumingii Gray.

Asterias (Heliaster) Cumingii Gray, Ann. and Mag. Nat. Hist., vi, p. 180, 1840.

Heliaster Cumingii Verrill, Trans. Connecticut Acad. Arts and Sci., i, part 2, 1867-1871, pp. 291, 333, 334, 344.

This species corresponds most nearly with *H. microbrachia* in the proportionate length of the free rays, but differs from it and from all the

other described species of the genus, in the character of the spines of the abactinal surface. There are six specimens in the collection, with from 24 to 37 rays each, the larger specimens having from 35 to 37 rays.

In one of the largest specimens, the longest radius measures about 75^{mm}; the diameter of the disk, about 60^{mm}; the entire length of the rays, about 48^{mm}; and the length of the free rays, from 12^{mm} to 16^{mm}. A small specimen affords the following measurements: longest radius, about 40^{mm}; diameter of disk, 28^{mm}; entire length of rays, about 28^{mm}; length of free rays, from 10^{mm} to 15^{mm}. In the largest specimen the free rays are somewhat conical in shape and taper rapidly to subacute points; in a second large one, and in the smaller ones, they are rather more elongate and slender proportionally, and taper less rapidly. They do not in any case differ sufficiently from those of *H. microbrachia* to furnish characters to distinguish these two species. The grooves between the united portions of the rays are very shallow and narrow, sometimes existing as mere creases, but are generally distinct. The limits of the disk are not more plainly marked than in *H. microbrachia*, but the specimens in the collection are rather more convex or inflated, due probably to their being better preserved.

The spines are of nearly uniform size and shape over the entire abactinal surface, excepting towards the tips of the rays, where they are smaller. They are larger and much more widely and regularly distributed than in *H. microbrachia*, and have a more regular arrangement than in *H. multiradiata*, in which they are equally large. The large and small specimens differ widely in the shape of the spines. In the former they are stout, mostly subconical or tooth-like in shape, blunt and rounded at the tips, though probably acute when not worn. Some of the spines, however, are short, cylindrical, or preserve nearly the same thickness throughout. They measure about 2.5^{mm} in length, about 1^{mm}, or slightly more in greatest diameter, and are placed from 2 to 5^{mm} apart. In the younger specimens they are much shorter and proportionally stouter, smallest at the base, and becoming enlarged or inflated and regularly rounded above, being decidedly bead-like in appearance. They are usually smallest over the median portion of the disk, where they are also more slender than elsewhere, and upon the outer part of the rays. As in the other species of the genus, there is no special arrangement of the spines upon the disk, but they are very regularly distributed, much more so than in the other species. Outside of the disk, in the larger specimens, they form more or less regular, radiating rows, three to each ray, the lateral rows bordering close upon the narrow grooves, and on the free portions of the rays extending rather far down upon the sides. The median row is entirely regular and single in one specimen, but in another it continues so for only about one-half the length of the rays from the disk, whence to near the tip, it forms an irregular series, two or three spines in width. The smaller spines toward the ends of the rays bear some resemblance to those of the young specimens above de-

scribed. In the latter the same general arrangement of the spines is apparent, but it is sometimes much less marked. On the free portions of the rays, especially in young specimens, the single spines of the median rows are often replaced by clusters of two to four small spines of the same general shape, closely placed. The color of the spines is dingy or yellowish white; of the abactinal surface, a bluish black, the latter color extending over the bases of the spines. The contrast between the spines and surface is, therefore, very striking, especially in alcoholic specimens.

The adambulacral spines form a single row of closely placed, regularly alternating, large and small spines (one to a plate), as in *H. microbrachia*, the latter being limited to the outer half of the grooves. The larger spines vary greatly in size and shape in the different specimens. In the largest specimens they are long and stout, rounded, subcylindrical, and neatly convex at the tips, which are sometimes slightly enlarged. Toward the actinostome they become slender and acute, and at the ends of the rays are very small. In another large specimen they are much smaller, somewhat more distantly placed, tapering, and subacute. This is also their usual character in the small specimens. Between the adambulacral and dorsal spines there are from three to four rows of spines, becoming reduced to two rows near the ends of the rays. These spines are mostly larger than those of the adambulacral series nearest to them, taper more or less, and are often slightly flattened. The lowest row follows closely after the adambulacral row, and the spines composing it are often smaller and more like the adambulacral than those higher up on the sides. The general appearance of the actinal surface is very much like that of some of the specimens of *H. microbrachia*.

Associated in the same collection with the specimens above described, is a single specimen (15524) which agrees more or less with the *Cumingii* in its general characters, but in the size, number, and arrangement of the spines, has more the appearance of *H. microbrachia*, and suggests the possible identity of those two species. By some it might be regarded as a new species. The longest radius is 72^{mm}; the diameter of the disk, about 40^{mm}; entire length of rays, about 50^{mm}; length of free portions of rays, about 16^{mm}; number of rays, 34. The spines are small, about as in *microbrachia*, but more regular, slightly tapering, rounded at the tips. They are very numerous, but less so than in *microbrachia*, and form a more or less regular, simple row on each side of the ray, between which they are distributed much as in *microbrachia*. On some parts of the surface, especially on the median part of the disk and the outer portions of the rays, they are short and globular in appearance, as in the young of *Cumingii*.

Professor Verrill (*loc. cit.*, p. 291) refers to *Heliaster Cumingii* of Gray, several specimens of a short-rayed *Heliaster* from Zorrites and Paita, Peru. These agree with the specimens above described in the

proportionate length of the free rays, and apparently also, to some extent at least, in the character and arrangement of the spines; but the writer depends entirely upon Professor Verrill's description for his information.

Only one lot of specimens (15523) of this species has been received. It was collected by Dr. W. H. Jones, U. S. N., at Chatham Island, one of the Galapagos Islands, in 1884, and by him presented to the National Museum.

Heliaster helianthus (Lam.) Gray.

Asterias (Heliaster) helianthus Gray, Ann. and Mag. Nat. Hist., vi, p. 179, 1840.

Heliaster helianthus Verrill, Trans. Connecticut Acad. Arts and Sci., i, part 2, 1867-1871, pp. 289, 334, 335; Perrier, Arch. Zool. Expér., iv, p. 351, 1875.

Several specimens of *Heliaster* in the collection, all from Ecuador and Peru, have been referred by the writer to this species. They agree more or less closely with one another in the proportionate length of the free rays and in the shape and arrangement of the spines, but differ considerably in the proportionate size of the latter. One specimen from Ancon, Peru (8832), corresponds very nearly with the specimens described by Professor Verrill, (*loc. cit.*, p. 289). The number of rays is 35; the longer radius measures 90^{mm}; the shorter, 58^{mm}; the free rays are from 32^{mm} to 38^{mm} in length. The adambulacral spines are of two sizes along the outer half of the ambulacral grooves, regularly alternating, one to each plate. The larger ones are long, stout, slightly enlarged, and rounded at the tips; the others are not more than half as long, slender, generally tapering, but seldom acute at the tips. Between the adambulacral spines and the first abactinal row, on each side of the rays, there are never more than five regular longitudinal rows of spines, generally only four, of which the two lower belong to the ventral plates and are close together. The spines of the ventral series are subequal in size and of about the same size and shape as the larger of the adambulacral spines, though sometimes tapering. A third ventral row is occasionally indicated toward the base of the rays by a few small spines.

The spines of the upper and lower lateral rows are somewhat smaller than the actinal and abactinal spines, and those of the median row are very small when present, being usually wanting altogether. The spines of the upper surface are of subequal size, rather short, stout, enlarging from the base upwards, and well rounded on top. Their arrangement is the same as described by Professor Verrill. They are more numerous and more closely placed than in *H. Cumingii* and *multiradiata*, but less numerous, larger, and more regularly arranged than in *H. microbrachia*.

One specimen, labeled simply Peru (15525), is much larger than the others, the longer radius measuring about 115^{mm}, the shorter about 70^{mm}. There are, however, only 32 rays. The spines of the upper sur-

face are larger than in the one above described and very stout, but have the same arrangement. Those of the median series of the rays and of the center of the disk are generally grouped in clusters of two to five spines, variable in size and irregularly placed. The ventral and lateral spines of the rays form five regular rows.

Three specimens from San Lorenzo (15522), having about the same size as the single specimen from Ancon (8832), are distinguished by their much smaller and more numerous spines, which, however, retain about the same shape and the same general arrangement. The spines are smaller than in many specimens of *microbrachia*, and on the disk generally form short, straight, connecting rows, dividing the surface into small, irregular polygonal areas. The spines forming the lateral abactinal rows of the rays are generally more slender than those upon the disk, while the median series are often grouped as in the large specimen above described. This species is readily distinguished from *H. Cumingii* and *H. microbrachia*, by the greater proportionate length of the rays and the arrangement of the spines upon the upper surface. From *H. multiradiata* it differs markedly in having more numerous and generally shorter rays, and in the arrangement of the spines upon the upper side of the rays.

RECORD OF SPECIMENS IN THE COLLECTION.

Ecuador; Dr. W. H. Jones, U. S. N., 1884:

Manta, sandy beach, young specimen (10993).

San Lorenzo (15522).

Peru; Dr. W. H. Jones, U. S. N., 1884:

Ancon (8832).

Paita (12574).

Precise locality not recorded (15525).

Peru; W. E. Curtis 1886 (15966).

Heliaster multiradiata GRAY.

Asterias (Heliaster) multiradiata Gray, Ann. and Mag. Nat. Hist., vi., p. 180, 1840. Verrill, Trans. Connecticut Acad. Arts and Sci., i, part 2, p. 292, 1867.

Heliaster Kumingii Xantus, Proc. Phila. Acad., xii, p. 568, 1860. Verrill, Trans. Conn. Acad. i, part 2, 1867-1871, pp. 292, 325, 344, 578, 594; Amer. Journ. Sci., xii, p. 357, 1869.

Two specimens of *Heliaster*, collected at the Galapagos Islands by Dr. W. H. Jones, U. S. N., have been referred by the writer to the *multiradiata* of Gray, the types of which were obtained at the same place. Dr. Gray's description is very brief, and it would be unsafe to apply it to any specimens collected elsewhere than at the special locality which furnished the types. In the measurements of the rays given by Gray, some of our specimens agree, if we consider the length of the rays to include both their free and united portions, or from the tips to the disk proper, which is much better defined in this species than in the others of the genus. In the use of the term compressed, in describing the shape of

the spines, Dr. Gray may possibly have meant flattened on top; but compressed spines do sometimes occur, and altogether, these features are exceedingly variable throughout the genus.

A comparison of the specimens in question with a large series of *Heliaster Kubingii*, from Lower California and the west coast of Mexico, proves that these two species are identical, and as Dr. Gray's name has priority, it must be used.

This species is readily distinguished from the others by its less numerous and proportionally longer free rays. The number of rays varies from 15 to 26, but only one specimen in the collection has fewer than 22 rays, 23 being the most common number. In nearly all the specimens, both dried and alcoholic, the disk proper is more or less elevated above the general contour of the abactinal surface, and is sometimes considerably inflated, though usually flattened on top. The free portions of the rays vary greatly in length, being occasionally almost as short proportionally as in some specimens of *H. helianthus*, and again may reach nearly to the disk. The rays are stout, well rounded, and retain their shape better than in the other species of the genus, due to the more rigid character of the skeleton. They are well defined close to the disk, their united portions being separated by deep channels, formed by the convex surfaces of the rays. The measurements of three specimens will serve to explain the proportional dimensions of the different parts:

	Specimen from Lower California.	Specimen from Lower California.	Specimen from Galapa- gos Islands.
	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>
Diameter of the disk.....	38	46	35
Longest radius.....	80	108	98
Entire length of rays.....	60	85	80
Length of free portions of rays.....	35	55 to 60	58 to 63

The spines of the upper surface, although exceedingly variable, are more or less characteristic of the species, in their size, shape, and arrangement. Those of the disk proper and of the inner median portions of the rays are larger than the others. They are very stout, generally much stouter than in any of the other species, sometimes exceedingly irregular, very short clavate, cylindrical, or tapering; the tips are broad and flattened on top, slightly excavate, or more or less fereate, sometimes compressed, or tapering and rounded. On the disk they are distantly separated, sometimes nearly uniform in size and shape, at others consisting of large and small intermingled, or smallest in the center of the disk.

On the upper surface of the rays, the spines form five radiating rows or series. The lateral rows, one on each side, are rather low down, and on the united portions of the rays are near together, though sometimes wanting. These rows are the most regular of the upper surface, and consist of the smallest spines, which are generally short, slightly taper-

ing, and blunt at the tips, usually closely placed, occasionally more distant. The three median rows form a broad series, of which the individual rows are generally distinct, sometimes very regular and well separated, at others irregular and more or less intermingled. Close by the disk proper they become reduced to a single row. On the inner part of the rays they consist, mainly, especially the median row, of large spines, similar to those of the disk, but the spines gradually decrease in size and become very small and short toward the tips of the rays. The madreporic plate is near the margin of the disk, and is generally very irregular in shape.

The adambulacral spines are comparatively small, numerous, cylindrical, or slightly compressed. The ventral spines are much larger, more distantly separated, stout, more or less compressed, varying in shape from slightly tapering to slightly clavate. Between the adambulacral row and the lateral abactinal row above described there are generally four regular rows, including the ventral series. The two upper rows are regular and consist of smaller spines than the ventral, resembling more those of the upper surface. The actinostome is relatively small compared with that of the other species.

RECORD OF SPECIMENS IN THE COLLECTION.

Lower California :

Cerro Blanco, off Cape Saint Lucas ; John Xantus, type of *H. Kubingii* (630).
La Paz ; L. Belding (15396) ; A. Forrer (10025).
Pichilnejo Bay (3628).

Mexico :

Mazatlan ; A. Forrer (10024).

Puerto Balandra, Gulf of California ; W. J. Fisher (8956).

Chatham Island, Galapagos Islands ; Dr. W. H. Jones, U. S. N. (12653).